Electrical Safety Work Practices
(For the Unqualified Worker)

The purpose of this handout is to provide general information and safe work practices related to work with or near electrical equipment. This information pertains to all employees at the Laboratory.

Electricity is an essential and familiar part of our daily life. Every time you plug/unplug anything from an outlet, there is a potential shock hazard. Do not overlook the hazards electricity poses or fail to treat it with the respect it deserves. Hazards include electric shock, electric burns, cardiac arrest, and arc/flash burns.

Upon reading this handout, you will:

- Understand the basics of electricity
- Recognize the dangers of electrical injuries
- Know the basic regulatory and Laboratory requirements
- Know how to protect yourself against electrical hazards

Understanding the Basics

To understand electricity and its components (voltage, current and resistance) consider a garden hose. At the valve, there is a certain amount of water pressure, which causes the water to flow. Both the water pressure and the opening of the valve determine the rate at which the water flows. Voltage is similar to water pressure, and current is similar to the water flow that moves along the hose. Resistance is similar to the effect of partially opening the valve. Voltage is measured in volts, current is measured in amps (or milliamps), and resistance is measured in ohms. In order to understand electrical hazards, it is important to consider voltage, current, and resistance.

Dangers of Electrical Injuries

Electric Shock

A person's body is an efficient conductor of electricity. If your body becomes a part of the electric circuit, it can cause an electrical shock. Shocks occur when a person's body completes the current path with:

- Both wires of an electric circuit
- One wire of an energized circuit and the ground
- A metal part that accidentally becomes energized due to a break in its insulation

Electrical shock can result in muscle contraction, breathing and/or heart stoppage, injuries caused from reflex action (such as falls from a ladder), internal and external burns, and death. Voltage levels greater than 50 volts are generally considered hazardous. A standard wall outlet is 120 volts, over twice the "hazardous" level. A common 100-watt light bulb draws a current of about 1 amp, and if someone accidentally contacts a current of only 1/10 of an amp, it may cause death. The severity of electric shock depends on the following:

- The amount of current flowing through the body
- The current's path through the body
- The length of time the body remains in the circuit
- The current's frequency

1 mA	Faint tingle
5 mA	Slight shock felt. Not painful but disturbing. Average individual can let go. Strong involuntary reaction can lead to other injuries.
6 – 25 mA Women 9 – 30 mA Men	Painful shock. Loss of muscular control. The freezing current or "let go" range. If extensor muscles are excited by shock, the person may be thrown away from the power source. Individuals cannot let go. Strong involuntary reactions can lead to other injuries.
50 – 150 mA	Extreme pain, respiratory arrest, severe muscle reactions. Death is possible.
1.0 – 4.3 A	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur, death is likely
10A	Cardiac arrest, severe burns, death is probable

The chart to the left shows the general relationship between the amount of current (in milliamps and amps) received and the reaction when current flows from the hand to the foot for just three seconds. (Chart information from TUV Rheinland of North America)

Insulators such as glass, mica, rubber or plastic used to coat metal and other conductors provide resistance to help stop or reduce the flow of electrical current (i.e., intact insulation on wiring). This helps prevent shock, fires, and short circuits. Dry skin has a fairly high resistance to electrical current; however, if the skin is moist or wet, it acts as a conductor. This means that anyone working with electricity in a damp or wet environment needs to exercise extra caution to prevent electrical hazards.

When a person receives an electrical shock, sometimes the electrical stimulation causes the muscles to contract. This "freezing" effect makes the person unable to pull free of the circuit. If a person is "frozen" to a live electrical contact, shut off the current immediately. If this is not possible, use a board or pole made of wood or any other non-conducting material to safely push, pull or pry the person away from contact. It's important to act quickly, but remember to protect yourself as well from electrocution or shock.

Note: If extensor muscles are excited by the shock, the person may be thrown away from the power source (dangerous if on a ladder or around dangerous equipment).

Burns

Burns are the most common shock-related injury. An electrical accident can result in an electrical burn, thermal contact burn, arc burn, or a combination of burns.

Electrical Burns

These are among the most serious burns and require immediate medical attention. They occur when electric current flows through tissues or bone, generating heat that causes tissue damage.

Thermal Contact Burns

These are the result of skin touching hot surfaces of overheated electric conductors, conduits, or other energized equipment. Thermal burns also can be caused when clothing catches on fire, as may occur when an electric arc is produced.

Arc/Flash Burns

Arc/flash burns are the result of high temperatures caused by an electrical arc or explosion near the body. These burns should be treated promptly. Extremely high-energy arcs can damage equipment, causing molten metal to fly in all directions.

Regulatory & Laboratory Requirements

Electrical risks are minimized when facilities and fixed and portable equipment are designed, installed, maintained, and used properly. OSHA regulations and national consensus standards such as NFPA 70, National Electric Code and NFPA 70E, standard for electrical safety in the workplace, provide necessary protective measures. OSHA provides electrical regulations and guidelines. NFPA 70 is intended for the proper design, installation, and inspection of electrical utilities. And NFPA 70E is intended for the safety of personnel with hazards arising from the use of electricity. To satisfy these requirements, Ames Laboratory has implemented policies and procedures for purchasing, inspecting, installing, and maintaining electrical equipment.

Labeling

Labeling is a requirement for electrical equipment and parts. Electrical equipment must be labeled and listed by a Nationally Recognized Testing Laboratory (NRTL) such as Underwriters Laboratories (UL), or approved for Ames Lab use by the AHJ. Listing of equipment includes items such as surge protectors, power strips, coffee pots, portable electric tools, laboratory equipment, etc. This requirement helps to assure that the design and manufacture of the equipment meets appropriate testing and safety.

Ground Fault Circuit Interrupters (GFCIs)

Ground fault circuit interrupters (GFCIs) provide personal protection against electric shock if you are physically in contact with conductive materials. Portable or permanent GFCIs shall be used in damp or potentially conductive locations such as near sinks and all outdoor locations. Ensure that your hands are not wet when plugging or unplugging equipment.

Protecting Yourself

Safe Work Practice's

It is Ames Laboratory Policy that work performed on or near energized electrical parts is prohibited.

- Live parts to which an employee may be exposed shall be **deenergized** before an employee may work near or on them, unless deenergizing introduces additional or increased hazards (deactivation of emergency alarm systems, shut down of hazardous location ventilation equipment, etc.) or is not feasible due to equipment design or operational limitations.
- If energized electrical work must be performed, a permit is required and must be approved by the Chief Operations Officer for Facilities and Engineering Services or the Division Director for Science and Technology. Only a qualified electrical worker (QEW) shall work on exposed live parts (involving either direct contact or by means of tools or materials) or near enough to them to be exposed to any hazard they present. You must also be a QEW to perform testing and troubleshooting.
- If exposed parts cannot be deenergized, safety related work practices shall be used to protect employees from electrical hazards (i.e., insulating gloves, insulated tools, blankets, etc.).
- All electrical equipment and conductors shall be considered energized until tested, and locked out and tagged out.
- Although testing and troubleshooting does not require an approved permit, safety related work practices (i.e., insulating gloves, insulated tools, insulated blankets, etc.) are still required.

- Don't enter areas that have barricades, barriers, warning signs, or electrical workers that are working on equipment. This area is considered the "Limited Approach Boundary" and unqualified personnel are not allowed.
- Conductive jewelry or clothing must not be worn if they might contact exposed energized parts.
- A minimum of 36 inches in depth and 30 inches in width must remain accessible and free of any obstructions in front of circuit breaker panels and electrical disconnects. Clear access is necessary for maintenance and emergencies.
- All electrical cabinets, panels, boxes, and fittings must be totally enclosed. If a knockout is missing or if there is another hole in the box, the hole or opening must be properly closed.
- Don't daisy chain (one into another) extension cords or power strips.
- Conspicuous signs are posted at the entrances to electrical rooms and similarly guarded locations to alert people to the electrical hazard and to forbid entry to unauthorized people.

Corded Electrical Equipment

Extension cords are permitted when used properly. They are only to be used as a **"temporary"** power source. Inappropriately used extension cords and power strips are cited frequently as safety violations.

- Three-conductor (grounded) extension cords must be used. Don't cut off the ground pin or compromise the ground protection in any way.
- Cords must be visually inspected by the user for defects (loose parts, deformed, or missing pins; pinched, crushed, or deteriorating outer insulation, etc.) before use or when relocating plugged-in equipment.
- Cords must be removed from service if a defect or damage is observed.
- Cords subject to pedestrian or vehicular traffic must be protected to prevent physical damage and minimize tripping hazard.
- Flexible cords and cables must be suitable for conditions of use and location.
- Flexible cords must not be:
    - Used as a substitute for fixed wiring of a structure
    - Attached to building surfaces
    - Run through holes or concealed in walls, ceilings or floors
    - Run through doorways, windows or other pinch points unless adequately protected
    - Spliced, taped or modified, unless specifically permitted by the National Electric Code (NEC)
    - Wired so that an exposed male plug is energized

Lockout/Tagout (LOTO)

Anytime an employee is exposed to contact with parts of fixed electrical equipment or circuits that have been deenergized, the circuits supplying energy to the equipment or parts must be locked and tagged out. In those cases, trained personnel will follow the procedure outlined in the ESH&A Program Manual. OSHA and Ames Laboratory prohibit unqualified persons from conducting any inspections, testing or repairs of electrical circuits or equipment. Additionally, OSHA prohibits unqualified employees from defeating any electrical interlock. When normally enclosed energized parts are exposed for maintenance or repair, OSHA requires that they be guarded (by barricades or attendants) to protect unqualified persons from coming in contact with the live parts.

Equipment

- Be aware of power supply devices that are utilized to power magnets, coils, lasers, etc. These devices may produce high currents, high voltage or both. Be cautious when handling conductive objects (e.g., screwdrivers) near exposed high current magnet leads. Bridging the leads can cause arcing.
- Never reach blindly into any areas or equipment, which may contain energized parts.
- Remain clear of any locked out equipment or systems where you see the "Danger – Do Not Operate" tags.

Don't Overload Circuits

Any limits inherent in the equipment must be recognized. Most office circuits are capable of carrying a current up to 20 amps. To prevent the circuit from overloading, a 20-amp circuit breaker will trip at 18 to 22 amps. So if a single circuit powers a computer setup, which draws approximately 6 amps, and a coffee pot draws 10-amps, a 16-amp load that is on a 20 amp circuit breaker should not trip. However, if you were to add a refrigerator or vacuum pump that requires 12 amps, the breakers should definitely trip. Don't get a false sense of security; a standard circuit breaker will not protect you from electrical shock. The circuit breaker is designed to avoid drawing excessive current, which in turn could overheat wires or connections and cause a fire.

Resetting Circuit Breakers

OSHA states that an "unqualified" employee may not reset a circuit breaker if it trips unless you can verify that it was caused by an overload condition rather than a fault condition. Even in this case, the breaker may only be reset once and only if doing so would not expose you to electrical parts energized above 50 volts. Any action beyond that would require a qualified employee (Facilities Electrician/Engineering Services Technician) who can evaluate and test the electrical circuits and equipment. You should stand to the side of the panel /disconnect when operating a circuit breaker.

Service and Repairs

Contact Facilities Services for repairs to building services at 4-3756.
Contact Engineering Services for repairs to equipment and instrumentation at 4-4823.
For questions about electrical safety contact ESH&A at 4-2153.

Medical Assistance

Seek immediate medical assistance for all electrical injuries (Occupational Medicine is located at G11 TASF). While burns and explosions seem obvious in their need for medical attention, electrical shock is the most elusive and possibly the more dangerous hazard. The effects of electrical shock may not appear until well after the incident occurs. So, if electrical shock does occur, it is crucial to first seek immediate medical attention regardless of whether you can see a wound, then report the shock, burn or explosion to your supervisor and ESH&A.